Liming of Vineyard Soils

By Thomas J. Rice, PhD
Soil Science Department, California Polytechnic State University, San Luis Obispo, CA

Liming vineyard soils to increase soil pH and raise calcium levels has been practiced for centuries in the humid areas of the world where soils tend to be more acid. Today, liming is increasingly practiced in the semiarid central coast regions of California, where liming of vineyards was unheard of even a decade ago.

Past agricultural practices, such as the addition of sulfur, acid-forming nitrogen fertilizers, and organic soil amendments, have caused soil acidification. Previously, most of these lands were either open space, range lands, or planted to grain crops.

To avoid unnecessary expense and protect the soil from environmental degradation when lime is used as a soil amendment, growers must assess their vineyards carefully to determine the proper types and amounts of liming materials to add.

What is lime?

Generally the term "lime," or "agricultural lime," refers to all limestone-derived materials used to neutralize acid soils, including ground limestone (calcium carbonate; CaCO3), hydrated lime (calcium hydroxide; Ca(OH)2), or burned lime (calcium oxide; CaO), with or without additions of magnesium carbonate, magnesium hydroxide, or magnesium oxide. In strict chemical terminology, lime refers to calcium oxide (CaO).

Quick field test for lime

To test for the presence of lime in your vineyard, take a spoonful of soil and drop a few drops of muriatic acid or 10% hydrochloric acid on it. If bubbling or fizzing occurs (due to carbon dioxide gas, CO2), this indicates the presence of carbonates or bicarbonates (lime). A quantitative determination of soil lime content requires laboratory analysis.

Lime and soil considerations

Adding lime increases soil pH, improves microbial activities, and increases the availability of nitrogen (N) and phosphorus (P). Adding excessive lime is expensive and undesirable for many reasons. Although the cost of lime, resultant yield increases, and increased grape quality determine the net benefit derived, lime is usually a profitable soil additive on strongly acidic (pH below 5.0) soils.

The following three facts about liming soil are particularly important:

- Lime additions generally improve soil structure, especially in clay soils, and in combination with phosphorus, may give larger increases in yields than lime alone.
- Toxic levels of soluble and exchangeable aluminum (Al) can be almost eliminated by raising the pH to between 5.2 and 5.5 with lime; further liming to a pH between 6.0 and

6.5 usually increases yields. The beneficial effects of raising the pH from 5.3 to 6.5 is likely due to an increase in biological activity, which increases the available nitrogen (N), molybdenum (Mo), and calcium (Ca).

- Adding high amounts of lime (raising pH higher than 6.5) may require addition of plant nutrients, such as iron (Fe), zinc (Zn), manganese (Mn), and phosphorus (P), which become less available to plants at a pH greater than 7.5.

Pure $CaCO_3$ is the standard against which other liming materials are measured, and its neutralizing value is considered to be 100%. The calcium-carbonate equivalent (CCE) is defined as the acid-neutralizing capacity of a liming material expressed as a weight percentage of $CaCO_3$.

Magnesium carbonate (MgCO3) will neutralize 1.19 times as much acid s the same weight of CaCO3; hence its CCE is 119%. The same procedure is used to calculate the neutralizing value of other liming materials.

Quality and fineness of limestone

Agricultural limestone's effectiveness depends on the degree of fineness, because the reaction rate depends on the surface area in contact with the soil. CaO and Ca(OH)2 are powders, but most limestones must be crushed to reduce the particle size and increase the surface area.

Because the cost of limestone also increases with fineness, materials that require minimal grinding, yet contain enough fine material to change pH rapidly, are preferred. Agricultural limestones contain both coarse and fine materials. Many states in the U.S. have laws that require that 75% to 100% of the limestone pass an 8- to 10-mesh screen and that 25% pass a 60-mesh screen. This way, there is fairly good distribution of both the coarse and fine particles.

Fineness is quantified by measuring the distribution of particle sizes in a given limestone sample. The effective calcium carbonate (ECC) rating of a limestone is the product of its CCE (purity) and the fineness factor.

Lime requirement: Different methods have been developed to determine the amount of lime needed to bring the pH of an acid soil to a desirable range. All of those analytical methods presently used take into consideration the buffering capacity of the soil.

A major problem of managing acid soils is to estimate the quantity of lime required to raise the soil pH to a certain level (see Table II). Non-legumes, such as grapes, can derive nitrogen from nitrogen fixed in legume cover crops. Much of the vine response to liming may actually be the pH responding to nitrogen fixation by the legume-Rhizobium relationship in a cover crop containing legumes.

Although many people still regard the primary effect of lime to be the provision of adequate soil calcium, its main value is really the addition of hydroxyl (OH^-) ions to the soil solution:

$$CaCO_3 + H_2O ====> Ca^{2+} + HCO_3^- + OH^-$$

The hydroxyl ions produced from the lime neutralize soil acidity, raise soil pH, and thus provide the most important effects of the liming process. Increased quantities of soluble and exchangeable calcium and magnesium are merely by-products of liming, although their greater amounts in limed soils may be beneficial to plants having high calcium requirements, such as legumes, and the increased calcium will help improve soil structure.

Conclusion

The decision to add lime to increase soil pH should depend on the goals of the vineyard manager relative to rootstock and scion selection. If lime is to be added, it is best to incorporate it at least one foot deep prior to planting of rootstock.

In established vineyards, there is no economical and effective method to significantly raise the subsoil pH by liming. The best one can hope for is to raise the pH of the upper six inches of soil and to increase the decomposition rate of any cover crop residue. Therefore, it is best to obtain a detailed soil map and soil test information prior to vineyard establishment to make a wise decision regarding soil liming.

References

1. California Fertilizer Association. 1995. Western Fertilizer Handbook. 8th edition. Interstate Publishers, Inc., Danville, IL.

2. B.D. Doss, W.T. Dumas, and Z.F. Lund. 1979. "Depth of lime incorporation for correction of subsoil acidity." Agron. J. 71(4): 541-544.

3. Himelrick, D.G. 1991. "Growth and nutritional responses of nine grape cultivars to low soil pH." Hort. Science 26: 269-271.

4. Miller, R.W., and D.T. Gardiner. 1998. Soils in our environment. 8th edition. Prentice Hall Publ., Englewood Cliffs, NJ.

5. Robinson, J. (editor). 1997. The Oxford companion to wine. Oxford Univ. Press, New York, NY.

6. Tisdale, S.L., W.L. Nelson, J.D. Beaton, and J.L. Havlin. 1993. Soil fertility and fertilizers. 5th edition. Macmillan Publ. Co., New York, NY.

7. Wright, R.J., V.C. Baligar, and R.P. Murrmann (ed.). 1991. "Plant-soil interactions at low pH. Developments in plant and soil sciences." Kluwer Acad. Publ., Netherlands.

Table1
Neutralizing value (CCE) of pure forms of some liming materietals

Liming Material	Neutralizing value %
Ca0	179
$Ca(OH)_2$	136
$CaMg(CO_3)_2$	119
$CaCO_3$	100
$CaSiO_3$	86

Source: Western Fertilization Handbook

Table II

Amounts of lime required to bring mineral and organic soils to the indicated pH according to soil buffer pH of the SMP buffer*

	Agricultural ground limestone ** (TPA)[b]			
	Mineral Soils			Organic Soils [c]
Soil Buffer pH	7.0[d]	6.5[d]	6.0[d]	5.2
6.80	1.4	1.2	1.0	0.7
6.60	3.4	2.9	2.4	1.8
6.40	5.5	4.7	3.8	2.9
6.20	7.5	6.4	5.2	4.0
6.00	9.6	8.1	6.6	5.1
5.80	11.7	9.8	8.0	6.2
5.60	13.7	11.6	9.4	7.3
5.40	15.8	13.4	10.9	8.4
5.40	17.9	15.1	12.3	9.4
5.00	12.0	16.9	13.7	10.5
4.80	22.1	18.6	15.1	11.6

** Shoemaker, McLean, and Pratt are soil chemists who developed the procedure*

*** Agricultural ground lime of 90% neutralizing power (TNP) or $CaCo_3$ equivalent, and fineness of 40%>100 mesh, 50%>20 mesh, and 95%>mesh*

[b] To convert tons per acre (TPA) to metric tons per hectare, multiply by 2.24

[c] Because of lower minerals content, organic soils are often suitable when limed only to pH 5.0 to 5.5.

d Desired pH level for the soil.

Source: Soils in Our Environment *and* Soil Fertility and Fertilizers